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VITAL ASPECT OF RESPIRATION AND CHANGE IN BRAIN SIGNAL DURING MEDITATION USING EEG AND MACHINE LEARNING

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Abstract

Practicing breathing can enhance an individual's antioxidant status in addition to helping them cope with life's pressures. An increase in antioxidant status is useful in reducing many free radicals that are formed when the food is processed by our body or when we are constantly around things like pollution, smoke, etc. Due to the less oxidation states in the body, the practitioner gets a boost in the immune system with less vulnerability to disease causing microbes [2]. A change of EEG and respiration signals that are rewarded after breathing exercises (e.g. Kriya Yoga), show the qualitative change in human life. After a specific week of meditation, EEG and breathing data were gathered and evaluated on a number of inexperienced mediators, former yoga practitioners, and monks. Spectral analysis, phase analysis, and classification were used to assess the objective marker for meditation [6]. In order to determine if breathing feature vectors and EEG data are reliable objective markers of meditation skill, this research article will incorporate methods employed in machine learning, comprising Decision Trees, Support Vector Machines(SVM), and Random Forest classifiers. This study examines the mindfulness meditation measure (mm), a mental exercise that allows one to sustain a state of relaxation.

Keywords: support vector machine, EEG, MM.

1. Introduction

Our breathing rhythm and patterns are influenced by our thoughts and feelings. There is a breath- emotion loop since our emotional and mental states are intimately correlated with our breathing. Consciously slowing down and deepening our breathing causes our mind to instantly become relaxed and at ease. Our mental and emotional states can be reclaimed in a matter of minutes. We can think of Diaphragmatic breathing as offering a massage to our internal organs and glands. Calm, deep belly breathing can also boost immunity by altering the gene expression of specific immune cells, according to a Public Library of Science study based on yoga breath exercises. (1)

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Different pole and lobe

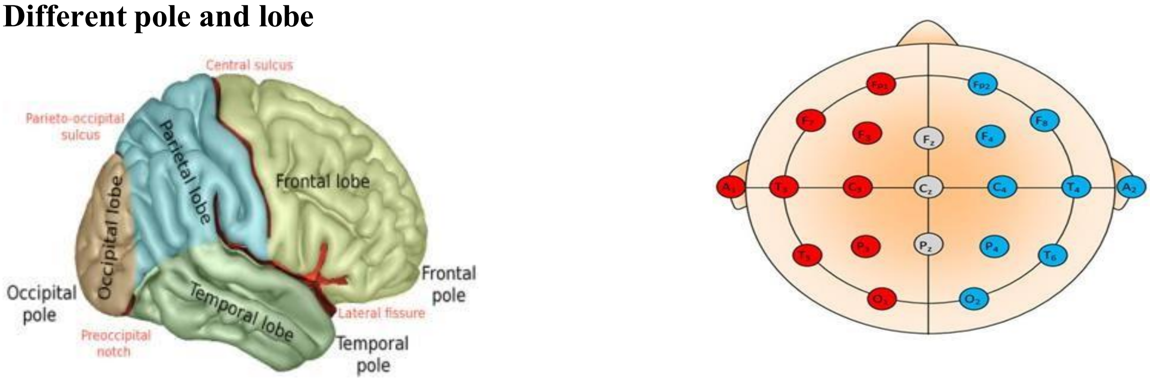

Fig 1.1 :

2. Related Works

Year	Number of training data	Number of channels	Type of stress	Experiment Duration	Frequency bands	Features	Classifier	Notes
2021	5	32	Mental Arithmetic	40 mins	Theta, Alpha, Beta	6 statistical feature, PSD, HOC, HJORTH PARAMETERS ,FRONTAL ASYMMETRIC ALPHA	SVM	GA based method out performed in detections of accuracy
2020	5	30	TSST	40 MINS	Delta, Theta, Alpha, Beta	Transitivity, modularity ,path length	SVM	Salivary cortisol level increase during TSST, classifier arrives with alpha and beta bandwidth
2020	5	30	Conscious breathing and meditation	45 mins	Gamma, High Beta, High Alpha	Relative change in amplitude and frequency	SVM	Remarkable change in brain signal during meditation
2022	7	4	mist	24 min	1-4 Hz, 4-7 Hz, 8-13 Hz, 14-30 Hz, 30-45 Hz	Delta , Theta, Alpha, Beta, Gamma	SVM	Comparison between stress

3. Methodology

3.1. Study Design:

A perspective interventional study was carried out in Ravenshaw University Cuttack in collaboration with Kalyani Diagnostic near SCB Medical Cuttack.

3.2 Study Population :

Boys & Girls studying in UG First year to PG Final years were included in this study.

3.3. Sample Size:

This study was carried out on 60 students.

3.4. Learning Period:

This study was carried out from 7th Nov to 7th Dec 2022, considering the academic

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year and

examinations of the student during COVID pandemic in year 2019.

3.5. Elimination Criteria:

Students practicing yoga sincerely and students who regularly engages their muscles through any kind of physical exercises are debarred from this research.

3.6. Materials used

a) Oximeter

b) Earphones

c) Weighing machine

d) Non-invasive automatic blood pressure monitor

e) EEG

f) Pre-designed Questionnaire

In order to determine the classification of mental stress, the stress study has looked at a variety of classifiers (2). The common and significant classifiers are Support vector machine (SVM), Decision Tree classifier, Random Forest classifier. The Hypothalamus Pituitary Adrenocortical Axis (HPA) and Sympathetic Nervous System (SNS) regulate humans' physiological responses (3). Before using that analysis method, the EEG data is subjected to a series of rigorous preprocessing steps to eliminate noise and artifacts.

EEG Report -

SUBJECTS (STUDENTS AGE(18-26)	TIME	BEFORE (KRIYA PRANAYAM) HIGH RANGE BETA SIGNAL	DURING (KRIYA PRANAYAM) BETA & ALPHA	AFTER (KRIYA PRANAYAM) ALPHA
SUBJECT-1	1MIN	29	17	9
	3MIN	33	18	12
	5MIN	34	17	9
	7MIN	13	17	8
	10MIN	20	17	9
SUBJECT-2	1MIN	29	18	8
	3MIN	30	13	9
	5MIN	29	14	9
	7MIN	12	13	12
	10MIN	26	16	9
SUBJECT-3	1MIN	21	18	10
	3MIN	32	13	8
	5MIN	29	18	12
	7MIN	23	12	8
	10MIN	29	14	9
SUBJECT-4	1MIN	25	18	9
	3MIN	14	16	12
	5MIN	15	12	11
	7MIN	15	16	12
	10MIN	25	16	10
SUBJECT-5	1MIN	26	15	11
	3MIN	25	13	9
	5MIN	31	12	11
	7MIN	27	18	12

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SUBJECTS (STUDENTS AGE(16-26)	TIME	BEFORE (KRIYA PRANAYAM) LOW RANGE BETA SIGNAL	DURING (KRIYA PRANAYAM) ALPHA	AFTER (KRIYA PRANAYAM) LOW RANGE ALPHA
SUBJECT-1	1MIN	15	9	9
	3MIN	14	9	10
	5MIN	14	12	10
	7MIN	13	10	10
	10MIN	15	8	10
SUBJECT-2	1MIN	15	10	10
	3MIN	15	8	9
	5MIN	12	10	10
	7MIN	12	11	10
	10MIN	14	10	10
SUBJECT-3	1MIN	15	10	9
	3MIN	12	12	10
	5MIN	12	8	10
	7MIN	13	12	10
	10MIN	13	11	8
SUBJECT-4	1MIN	12	11	10
	3MIN	12	11	9
	5MIN	14	8	9
	7MIN	14	8	9
	10MIN	14	8	10
SUBJECT-5	1MIN	12	12	9
	3MIN	14	11	9
	5MIN	15	8	8
	7MIN	13	10	9

BRAIN WAVE SIGNALS THROUGH EEG (IN HZ)				
SUBJECTS (MONKS AGE(22-60))	TIME	BEFORE (KRIYA PRANYAM) ALPHA	DURING (KRIYA PRANYAM) THETA	AFTER (KRIYA PRANYAM) THETA & DELTA
MONK-1	1MIN	12	4	2
	3MIN	8	7	3
	5MIN	10	8	2
	7MIN	12	7	2
	10MIN	12	8	2
MONK-2	1MIN	11	4	4
	3MIN	10	8	2
	5MIN	12	8	3
	7MIN	10	6	3
	10MIN	9	6	2
MONK-3	1MIN	11	7	3
	3MIN	11	7	4
	5MIN	12	5	2
	7MIN	9	7	3
	10MIN	8	7	2
MONK-4	1MIN	11	7	2
	3MIN	8	7	4
	5MIN	9	4	2
	7MIN	12	7	3
	10MIN	9	5	2
MONK-5	1MIN	12	5	2
	3MIN	8	4	3
	5MIN	12	4	3

The most frequent physiological aberrations that affect the EEG signal include eye blinks, head and body movements, electrolyte concentration changes at electrodes and DC offset,

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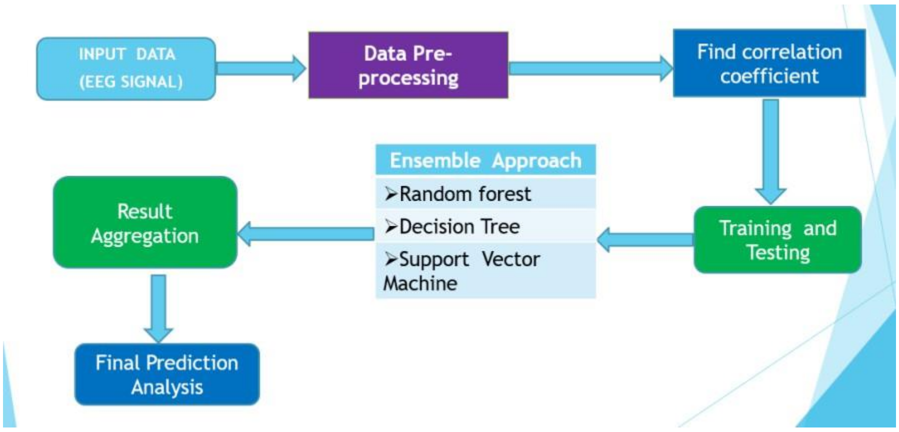
sambhavimudra practice, and mindful breathing.

4. Key observations

The heart's beating rate was significantly lowered by mindful breathing, which was followed by regul- ar inhalations and exhalations. This reduced stress brought on by anxiety. Remarkably, the effects of suppressing some types of emotions influence our body metabolisms, leading to elevated blood

pressure and heart rate. For example, in a group of students debating among themselves to prove their theories are true, the student who participated the least was found to be most stressed out due to anxiety, which was caused by suppressing expression. A reduction in breathing rate and a subsequent drop in blood pressure were the results of synchronizing aerobics or any physical exercise with the regulated breathing pattern that is widely recognized as "ASANAS."

4.1 Proposed Model



EEG Signal Analysis

Figure 4.1.1:

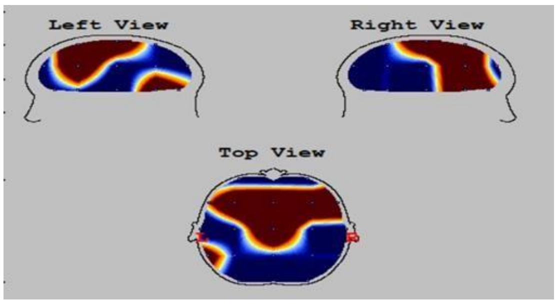


Figure 4.1.2:

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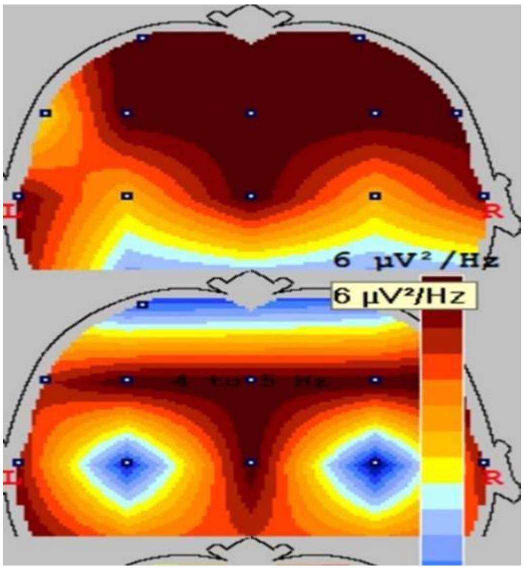
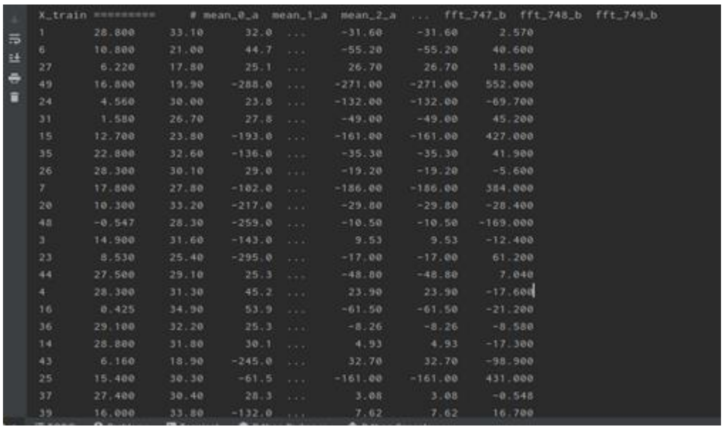


Figure 4.1.3:

4.2. Data Processing

Data cleaning and transformation processes, which is a subset of data readiness process, involves performing various operations on unprocessed data to prepare it for further task in handling data (4). It has always been a preliminary stage in the procedure of data mining. It describes preparing data for analysis by cleaning, converting, and integrating it. (3). Data preparation aims to enhance data quality and tailor the data to the specific requirements of the intended data mining task.



X_train =========	# mean_0_a	mean_1_a	mean_2_a	...	fft_747_b	fft_748_b	fft_749_b
1	28.800	33.10	32.0	...	-31.60	-31.60	2.570
6	10.800	21.00	44.7	...	-55.20	-55.20	40.600
27	6.220	17.80	25.1	...	26.70	26.70	18.500
49	16.800	19.90	-288.0	...	-271.00	-271.00	552.000
24	4.560	30.00	23.8	...	-132.00	-132.00	-69.700
31	1.580	26.70	27.8	...	-49.00	-49.00	45.200
15	12.700	23.80	-193.0	...	-161.00	-161.00	427.000
35	22.800	32.60	-136.0	...	-35.30	-35.30	41.900
26	28.300	30.10	29.0	...	-19.20	-19.20	-5.600
7	17.800	27.80	-102.0	...	-186.00	-186.00	384.000
20	10.300	33.20	-217.0	...	-29.80	-29.80	-28.400
48	-0.547	28.30	-259.0	...	-10.50	-10.50	-169.000
3	14.900	31.60	-143.0	...	9.53	9.53	-12.400
23	8.530	25.40	-295.0	...	-17.00	-17.00	61.200
44	27.500	29.10	25.3	...	-48.80	-48.80	7.040
4	28.300	31.30	45.2	...	23.90	23.90	-17.600
16	0.425	34.90	53.9	...	-61.50	-61.50	-21.200
36	29.100	32.20	25.3	...	-8.26	-8.26	-8.580
14	28.800	31.80	30.1	...	4.93	4.93	-17.300
43	6.160	18.90	-245.0	...	32.70	32.70	-98.900
25	15.400	30.30	-61.5	...	-161.00	-161.00	431.000
37	27.400	30.40	28.3	...	3.08	3.08	-0.548
39	16.000	33.80	-132.0	...	7.62	7.62	16.700

Figure 4.2.1:

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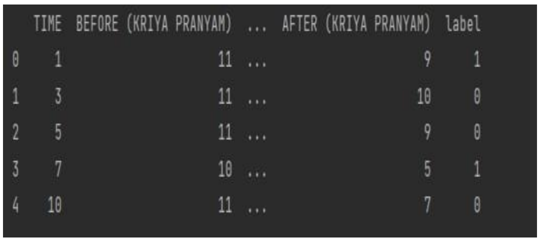
4.3. Testing the dataset

Independent test data, distinct from the dataset used for training, evaluating a machine learning model's generalization performance relies heavily on the training dataset of a trained model. This test set provides an unbiased analyzing the accuracy of a model's predicted outcomes on unseen instances, thereby demonstrating the success of the training phase and the model's ability to perform on unseen data. While the test set should ideally remain unchanged during the final evaluation to maintain objectivity, iterative model refinement may involve using validation sets (subsets of the training data) to guide hyper-parameter tuning and model selection.

There are two primary criteria for testing data: It should:

- Authentically depict the dataset.
- Have enough size to produce accurate forecast.



	TIME	BEFORE (KRIYA PRANYAM)	...	AFTER (KRIYA PRANYAM)	label
0	1	11	...	9	1
1	3	11	...	10	0
2	5	11	...	9	0
3	7	10	...	5	1
4	10	11	...	7	0

Figure 4.3.1:

4.4. Classification Algorithms

4.4.1. Support Vector Machine (SVM)

The fundamental objective of an SVM classifier aims to identify the best possible decision boundary, that effectively separates data belonging to Kriya Yoga practitioners, non-practitioners, and monks,

enabling efficient future classification. In this case each table consists of three individual columns which possess data regarding the signals, (alpha, theta and delta) emitted from our brain before, after and during the kriya pranayama. And through this analysis we came to conclusion that pranayama acts as a crucial factor in our respiration and respiration control these signal emissions.

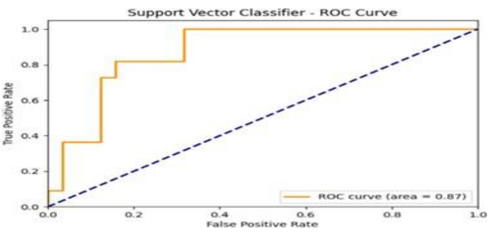


Figure 4.4.1 :

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4.4.2. Random Forest Classifier

4.4.3.

A Random Forest classifier employs an ensemble of decision trees for prediction. Each tree independently determines a class, and the final classification is reached through a majority vote among the trees.

This algorithm has the lowest accuracy of 85 percentage.

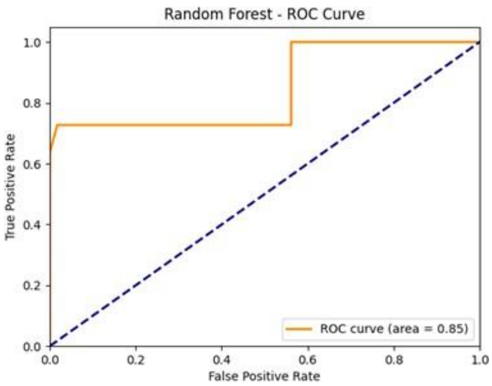

Figure 4.4.2 :

4.4.4. Decision Tree Algorithm

Although it may be applied to bothclassification and regression problems, decision trees are a super

-vised learning technique that are most often employed to solve classification difficulties (5). In a decision-tree classifier, dataset features are used to define internal nodes, which are connected by branches representing decision rules that ultimately lead to leaf nodes representing the final classification.

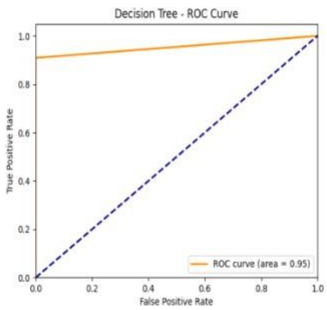

Figure 4.4.3 :

In correlation matrix we calculate the interdependence of each attributes with other attributes including itself. This provides a temperature scale in which a cooler colour represents less

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dependency and warmer colour represents more dependency.

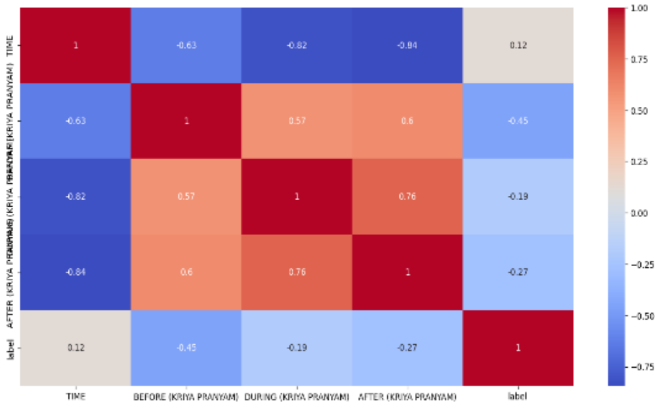
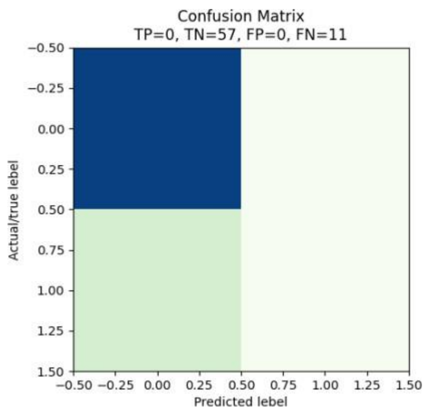


Figure 4.4.4 :

4.5. Confusion Matrix

A confusion matrix is used to evaluate the performance of a classification model by examining four distinct scenarios based on actual versus predicted outcomes:

1. **True Positive (TP)**: This indicates that the model has accurately predicted a positive outcome.
2. **True Negative (TN)**: This signifies that the model has correctly identified a negative outcome.
3. **False Positive (FP)**: This occurs when the model incorrectly predicts a positive result, although the actual outcome is negative.
4. **False Negative (FN)**: This happens when the model wrongly predicts a negative result, even though the actual outcome is positive



$$precision = \frac{TP}{TP+FP}$$

$$recall = \frac{TP}{TP+FN}$$

$$F1 = \frac{2 \times precision \times recall}{precision + recall}$$

$$accuracy = \frac{TP+TN}{TP+FN+TN+FP}$$

Figure 4.5.1:

In the provided sample the best algorithm is random forest to use in confusion matrix as it has highest accuracy and precision.

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	accuracy	F1-score	Recall	precision
Random Forest	86.66	86.59	87.77	86.67
Logistic Regression	33.33	16.66	33.34	33.34
Support Vector Machine	80.00	79.54	81.11	80.00

5. Conclusion

Research work is to analyze the EEG signal during various activities and the temporal change in brain which continues practice of meditation. It results a permanent change in volume and density of hippocampus and amygdala, and activate the frontal context of human brain through EEG.

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